

EFFECT OF COMBINED UNDERWATER PROCESSING AND MILD PRECUT HEAT TREATMENT ON THE SENSORY QUALITY AND STORAGE OF FRESH-CUT CANTALOUPE MELON

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Received for Publication January 8, 2009
Accepted for Publication December 7, 2009

ABSTRACT

Improvement of storage quality of fresh-cut cantaloupe using a combination precut heat treatment and a modified underwater cutting treatment was determined. Eating quality was evaluated using descriptive sensory analysis, and fruit integrity was measured with respiration, cell leakage and product weight loss. Treatments included (1) control (no treatment); (2) making the first longitudinal cut underwater; (3) mild precut heat treatment in a water bath at 60C for 60 min; and (4) combination of precut heat treatment and the underwater cutting methods. Precut heating and processing underwater resulted in more intense fruity/melon flavor compared to conventional processed fresh-cut fruit. Reduced electrolyte leakage and enhanced membrane integrity were observed in all three experimental treatments, as evidenced by lower conductivity measurements. The underwater cut and combined treatments significantly reduced respiration during fresh-cut storage, reflecting less physical stress and membrane damage. Weight loss was not significantly affected by any treatment during fresh-cut storage.

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PRACTICAL APPLICATIONS

There is a steady increase in the consumption of fresh-cut produce. To enhance the storage quality of fresh-cut cantaloupe melon, two minimal processing techniques were examined separately and combined. The methods are mild heat treatment of the whole melon at 60C for 60 min then cooling to 4C for 24 h, cutting the cantaloupe in half and removing the seeds while submerged in a calcium chloride and water solution, and the combination of the two treatments. These methods are simple and can be utilized by small or large processors to maintain sensory quality and fruit integrity during storage.

INTRODUCTION

As consumption of fresh-cut fruits increases, enhancing the sensory quality, food safety and storage stability of these fruit commodities has become of paramount importance. Various processing methods have been actively investigated to enhance the quality attributes in fresh-cut fruits. One such processing treatment is the method of mild heat (50–60C for 60 min) prior to cutting (Lamikanra *et al.* 2005 and Lamikanra and Watson 2007). The use of mild heat pretreatment reduced the percent change in respiration and moisture loss during storage of the cut fruit. Furthermore, sensory evaluations of these fruit resulted in increased intensities of desirable attributes such as fruity melon and sweet aromatic flavors (Lamikanra *et al.* 2005). Other research have shown that hot water treatments (43–53C for up to 2 h) of various commodities are beneficial in reducing microbial loads, thus enhancing food safety (Fallik 2004). The application of mild heat pretreatment (45C for 10 min) and calcium (CaCl_2) has been shown to impose a beneficial reduction in wound-induced ethylene production and percent change in respirations in plums (Serrano *et al.* 2004). Heating has also been shown to delay fruit ripening and increase the time to senescence, reduce sensitivity to chilling injury and enhance general quality and safety (Couey 1989; Lurie 1998; Annous *et al.* 2004; and Solomon *et al.* 2006). Recent studies suggest that mild heat pretreatment (60C for 60 min) of whole cantaloupes coupled with 24 h post-treatment storage at 4C induces the formation of heat shock proteins (Lamikanra and Watson 2007). Such heat shock proteins confer a defensive response in fresh cantaloupe that enhances both the storage stability and sensory quality of this commodity (Lamikanra and Watson 2007).

The concept of the underwater processing of fruit has been suggested as a means to boost the shelf life of fresh-cut fruit and vegetables (Lurie 1998). Recent research demonstrated that underwater processing of whole cantaloupe yielded fresh-cut cantaloupe with improved storage stability in comparison to

the traditional fresh-cut cantaloupe available in the market. Lamikanra *et al.* (2010) observed that calcium chloride added to the water before cutting also improved the fruit quality. This technique washes out enzymes that are released during the cutting process and minimizes the effects of deleterious wound signals that facilitate tissue degradation (Lamikanra *et al.* 2010). Calcium has also been suggested as a possible mechanism in the potential modification of wound signaling that is considered to be responsible for the onset of a defense response, and which could result in enhancing shelf life and storage (Serrano *et al.* 2004). The presence of calcium in the underwater processing has been shown to inhibit microbial growth (Lamikanra *et al.* 2010).

In an effort to further enhance the sensory quality during storage of fresh-cut cantaloupe treated by the above mentioned process techniques, an alternate methodology was devised to combine both the mild heat precut treatment and the modified underwater processing technique to fresh-cut cantaloupe melon. Because cutting the entire melon under water is awkward, preliminary work indicated that the first cut, seed removal and holding for 5 min in water resulted in similar advantages to completely cutting in water (Lamikanra *et al.* 2006). Therefore, the combination treatment consisted of mild heat precut treatment with the first cut and seed removal occurring underwater with the water containing calcium chloride. Thus, the objective of this study was to determine the combined effect of both mild heat precut treatment and underwater processing technology on the sensory quality and tissue integrity of fresh-cut cantaloupe melon.

MATERIALS AND METHODS

Fruit Preparation

Cantaloupe melon (*Curcumas melo* L. var. *reticulates*) was obtained from Winn Dixie Market Place (New Orleans, LA designated market area). All melons for the treatments were selected from one case of comparable sized melons. Melons were selected for similar rind coloring. Due to the treatments being done on whole precut melons, the melon effect is confounded with the treatment effect. The combining of data from three or four melons of like size and rind color was used to reduce the chances of an underdeveloped melon appreciably skewing the data. Heat treatment was conducted by placing whole, uncut fruit into a water bath maintained at 60C for a period of 60 min. Internal temperatures reached 50 to 55C. Preliminary work proved that this was the ideal temperature to stabilize enzyme activity without causing cell destruction. To compensate for melons floating, they were rotated every 5 min. The treated

fruit was then cooled to 4C in a refrigerator and stored for 24 h at 4C prior to processing. Before processing, the fruit was cleaned in water at 4C containing sodium hypochlorite (100 ppm free chlorine) at pH 6.5 and scrubbed with a brush. Underwater processing of fruit was carried out in water using a fruit submersible tank (~57 L) developed at the ARS-Southern Regional Research Center. Fruit submerged in treated water (7 ppm free chlorine and 0.5% calcium chloride; 4C) was cut longitudinally into two halves based on previous work by Lamikanra and Watson (2004). After removal of seeds from the fruit cavity, halved fruit was permitted to stay inside the treatment water containing calcium chloride for approximately 5 min. Each halved fruit section was immediately delivered to the cold room and further cut longitudinally into four sections. The skin was removed and cubes (~2–3 cm × 2.5 cm) and/or bite-size melon chunks for sensory evaluation (~ 3–4 g) were cut. Each treated melon (two per treatment for sensory evaluation and two per treatment for other analyses) was tested throughout storage. The whole experiment was repeated. The two replications were done 4 weeks apart. A third replication was done on the nonsensory analysis because these tests were done on only one melon at a replication. Therefore, all the nonsensory analyses were accomplished on three melons. Approximately 50 g of cubes from each melon were placed in a single layer into 24-oz (about 1 L) Juice Catcher bowl (The Brenmar Company, La Vista, NE), and stored at 10C for 1, 5, 8, and 14 days. Storage temperature of 10C was utilized to simulate less than ideal conditions of storage. Good manufacturing practices and sanitary conditions were strictly adhered to during processing and all subsequent handling stages.

Electrolyte Leakage (Conductivity)

Fresh-cut cantaloupe was placed in a juice catcher and stored at 10C. Each treatment was performed in duplicate for the duration of the study. On the respective sample day, cut fruit from each of the four treated melons (40 g) was placed in separate 0.5 L glass jars containing 200 mL of distilled water. Conductivity reading was taken at both 1-h and 24-h time intervals for each sample using a Hanna Instruments conductivity meter (Hanna Instruments, Woonsocket, RI). The conductivity value was considered to be the net value when the 1-h conductivity reading was subtracted from the 24-h conductivity reading. Results are reported in ppms. Higher conductivity of exudates reflects greater rates of electrolyte leakage, indicating damage to cell walls resulting in leakage of cell contents (Cabrera and Saltveit 1993).

Determination of Respiratory Activity

Cut fruit from each treated melon (50 g) was placed into separate glass jars (0.5 L) fitted with airtight lids equipped with a rubber septum and stored

at 10C. Analysis for CO₂ and O₂ gas in the headspace was carried out by withdrawing a sample of gas (8 cm³) with a needle syringe attached to a Mocon Pack Check 650 analyzer (MOCON\Modern Controls Inc., Minneapolis, MN) through the rubber septum of the respective jar on each storage day. Differences in percent change in respiration between samples during storage were assessed from the composition of these gases by the Mocon analyzer as described by Lamikanra and Watson (2004, 2007).

Weight Loss

Initial fruit weight was determined immediately after fruit processing. On each sampling day, fruit stored in low-profile Juice Catchers was transferred into new tared containers that had been maintained at the storage temperature. The percent difference in the weight of fruit on the sampling date from weight of fruit when freshly processed is an indicator of moisture loss during storage (Lamikanra and Watson 2004; Lamikanra *et al.* 2005).

Descriptive Sensory Evaluation

Six sensory panelists trained in descriptive analysis techniques as described by Johnsen and Kelly (1990) evaluated the flavor and texture quality of the fresh-cut cantaloupes. A linear universal intensity scale based on the Sensory Spectrum Descriptive Analysis Method (Meilgaard *et al.* 2007) was used to evaluate the flavor and texture attributes of melons. The study consisted of six sessions (rep 1-first three sessions [storage days]; and rep 2-second three sessions [storage days]). The panelists evaluated the flavor and texture of the fresh-cut fruit on storage days 1, 5 and 8. Samples stored to 14 days for sensory were not evaluated due to possible mold contamination. A sensory session warm-up melon sample (processed the day of the panel) and four randomly presented test samples were evaluated by the panelists at each session. Five randomly selected fruit pieces from the 16 oz plastic storage container were distributed into 6 oz glass custard cups set in foam bowls (labeled with three-digit numbers) and covered with inverted 125 mm watch glasses. The melons were served to the panelists at 10-min intervals at ambient temperature. The flavor and texture attributes (Fig. 1) used to evaluate the samples were adapted from Bett (2002). Panelists were instructed to smell the samples initially to observe aromatic intensity before proceeding with an oral assessment of flavors. They were instructed to rate the intensity of the greater aroma or flavor. A mental average score was recorded for those flavor descriptors in which a varying range of intensity was noted during oral evaluation of the five fruit pieces. An individual panelist evaluated cubes from the same melon throughout the storage period. Half of the panelists evaluated samples from one melon and the other half evaluated samples from the other melon. Purified water was

Sensory Attribute	Definition
1. Fruity/Melon	A mixture of aromatics associated with melons (cantaloupes, honeydews, watermelon, etc.) and other fresh fruit.
2. Cucurbits	Aromatics associated with cucurbits such as pumpkins, cucumbers, and squash.
3. Citrus	Aromatics associated with fresh citrus products.
4. Sweet Aromatic	The aromatic associated with materials that also have a sweet taste such as honey, caramelized sugar, and cotton candy.
5. Musty	Aromatic associated with mold or dirt such as geosmin and methylisoborneol .
6. Chemical	Aromatics commonly associated with solvents, cleaning compounds, and hydrocarbons.
7. Rancid/Painty	Aromatic associated with oxidized fats and oils.
8. Fermented	Aromatic associated with fermented fruit or sugars such as dried peaches, prunes, or wine.
9. Sweet Taste	The taste on the tongue associated with sugars.
10. Wetness	The amount of moisture, due to an aqueous system, on the surface
11. Hardness	The force to attain a given deformation between molars
12. Cohesiveness	The degree to which sample deforms rather than crumbles, cracks, or breaks.
13. Crispness	The force and noise with which a product breaks or fractures (rather than deforms) when chewed with molar teeth (first and second chew).
14. Juiciness	Definition: The amount of juice/moisture perceived in the mouth during first five chews.

FIG. 1. DESCRIPTIVE SENSORY ATTRIBUTES FOR FRESH-CUT CANTALOUPE MELONS

obtained from a reverse filtering system (Hydrotechnology Inc., Valencia, CA) and used to cleanse the palate between samples. Unsalted crackers were available between samples to cleanse the palate.

Statistical Analysis

Means and standard errors were calculated and plotted. Significant differences were based on analysis of variance. All data sets were analyzed using

a two-way factorial design (Treatment by Storage Day) using Proc GLM (SAS Release 9.1, SAS Institute, Inc., Cary, NC). Tukey's studentized range (honestly significant difference) was used to compare treatment means. Significance is considered at $P < 0.05$ for all data. Sensory data consists of two replications for each treatment. Two melons were evaluated at each replication for each treatment. One-half of the panelists evaluated one melon throughout the storage period, while the other half of the panelists evaluated the other melon. Nonsensory data were collected twice on one melon per treatment throughout storage. The two data per melon were averaged for the replication. These data were replicated three times at 2- to 4-week intervals.

RESULTS AND DISCUSSION

Electrolyte Leakage (Conductivity)

Overall the sampling days, the conductivity of the no treatment (control) samples was significantly higher on average (365.1 ppm) than the other three treatments. The precut heated fruit had an average conductivity value (overall sampling days) of 320.3 ppm. The fruit that was underwater processed had an overall average conductivity value of 312.4 ppm. Additionally, the mildly precut heated fruit that was underwater processed had an overall average value of 314.3 ppm. The effectiveness of the precut heat treatment and the underwater cutting compared with the control fruit is clearly shown in Fig. 2. Precut heating of cantaloupe is known to enhance the integrity of fruit tissue (Lamikanra *et al.* 2005). However, the means of the conductivity values observed in the precut heated fruit cut under water were comparable to the underwater process treatment throughout the storage time. Calcium is known to enhance the firmness of fruit tissue by improving the stability of the cell walls through covalent bonding (Lamikanra and Watson 2007) which occurred when this fruit was processed underwater. High conductivity is indicative of leakage of intracellular ions and is a direct result of damage to the membranes (Ade-Omowaye *et al.* 2003). These results indicate that both the mild heat pretreatment and making the first cut under calcium-treated water reduced cell wall damage which in turn reduced cell leakage. The combination of the two treatments did not result in a synergistic effect that was greater than the individual results of the two treatments.

Respiratory Activity

Combining all sampling days, the control treatment mean (4.88%) had significantly higher respiration than the combined treatment means (mild heat pretreatment and underwater first cut) (3.23%). The underwater first cut mean

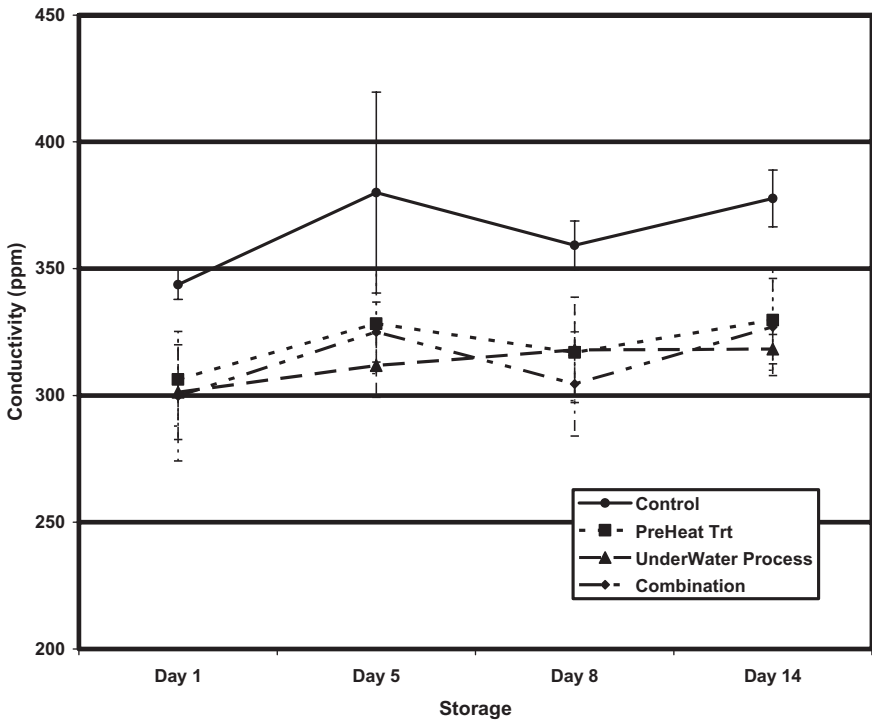


FIG. 2. ELECTROLYTE LEAKAGE OF FRESH-CUT CANTALOUPE SUBMITTED TO FOUR PROCESSING TREATMENTS AND STORED AT 10C

Means ($n = 3$) of conductivity (ppm). Processing treatments were: Control = fruit processed in open air (no heat treatment), Preheat Trt = fruit precut heat treatment at 60C for 1 h and refrigerated for 24 h, Underwater Process = fruit with first cut made underwater and held for 5 min, Combination = fruit precut heat treatment at 60C for 1 h and processed underwater. Vertical bars represent standard error of the means.

(4.54%) and the mild heat precut heat treatment mean (3.50%) were between the control and combined treatments and not significantly different from either of these treatments. There were no significant improvements among any of the treatments in this study at day 1 for CO₂ respiration (Fig. 3). On day 5, the precut heated cantaloupe that was underwater processed had lower CO₂ respiration than was noted in the cantaloupe processed underwater. On Day 8, CO₂ respiration value for the control fruit was greater than for the precut heat treatment. The value for the precut heated fruit that was underwater processed was even less. Overall, mild heat treatments (alone or combined with underwater cutting) slowed the respiration of fresh-cut cantaloupe the most (Fig. 3). Underwater-processed precut heated cantaloupe yielded a lower CO₂ percent

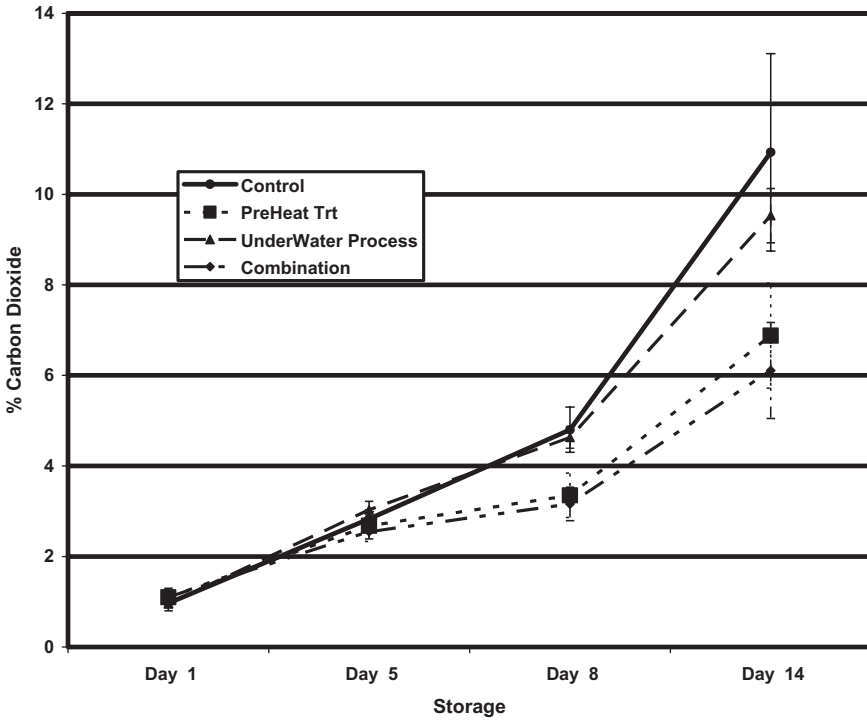


FIG. 3. CO₂ RATE OF RESPIRATION OF FRESH-CUT CANTALOUPE SUBMITTED TO FOUR PROCESSING TREATMENTS AND STORED AT 10C

Means ($n = 3$) of % change. Processing treatments were: Control = fruit processed in open air (no heat treatment), Preheat Trt = fruit precut heat treatment at 60C for 1 h and refrigerated for 24 h, Underwater Process = fruit with first cut made underwater and held for 5 min, Combination = fruit precut heat treatment at 60C for 1 h and processed underwater. Vertical bars represent standard error of the means.

change in respiration than was observed in the other treatments after 14 days. The reduced CO₂ respiration present in the precut heated cantaloupe that was underwater processed was prevalent throughout the 14 days of storage. Hot water treatments have been shown to delay both climacteric peaks of CO₂ and fruit softening in Japanese apricots (Zisheng 2006). This treatment seems to be effective on controlling respiration in fresh-cut cantaloupe also. Comparison of the underwater-processed precut heat treatment fruit with the precut heat treatment fruit alone suggest that precut heat treatment reduced physical stress and damage to plasma membranes, thereby lowering the CO₂ rate of respiration. Controlling the respiration of fresh-cut fruit has positive implications for preserving the quality. This could possibly extend the shelf life of fresh-cut

fruit, but that would need to be examined for microbial safety before sensory quality could be evaluated.

Weight Loss

During the storage period, the means between the four experimental treatments are not significantly different for weight loss. The mildly precut heat treatment cantaloupe that was underwater processed and stored at 10C displayed, generally, less percent weight loss than the other treatments, but there were no statistically significant differences (Fig. 4). Previous research by Lamikanra *et al.* (2005) suggested that mildly precut heat treatment

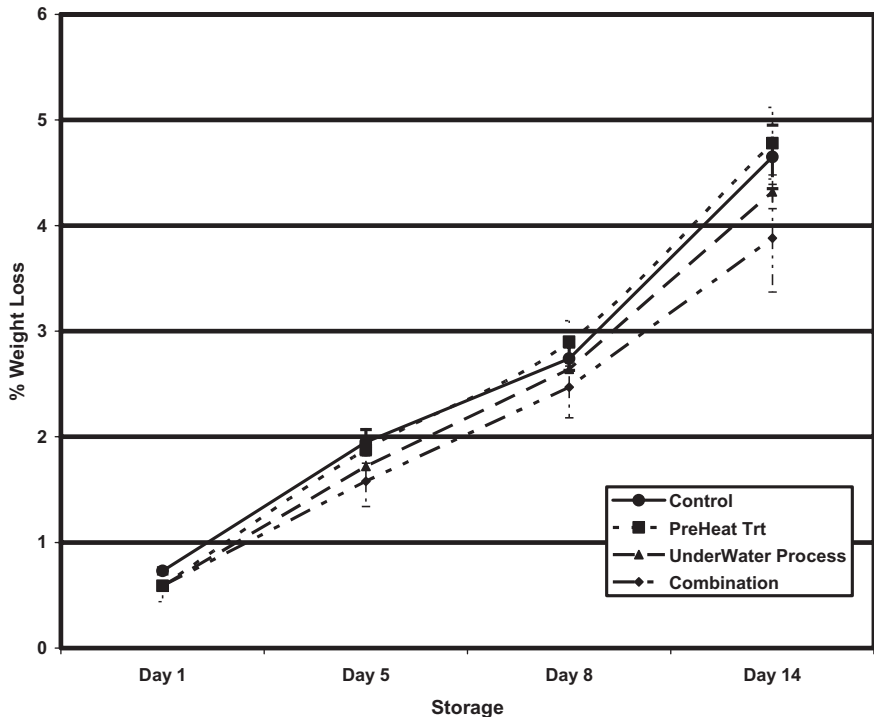


FIG. 4. WEIGHT LOSS OF FRESH-CUT CANTALOUPE SUBMITTED TO FOUR PROCESSING TREATMENTS AND STORED AT 10C

Means ($n = 3$) of % change. Processing treatments were: Control = fruit processed in open air (no heat treatment), Pre-heat Trt = fruit precut heat treatment at 60C for 1 h and refrigerated for 24 h, Underwater Process = fruit with first cut made underwater and held for 5 min, Combination = fruit precut heat treatment at 60C for 1 h and processed underwater. Vertical bars represent standard error of the means.

cantaloupe had lower moisture loss than control cantaloupe due to increased protoplasmic viscosity and loss of membrane permeability. It has also been suggested by Javanmardi and Kubota (2006) that a higher rate of transpiration could be responsible for increased weight loss in fruits, such as tomatoes. It is possible that these effects coupled with the maintenance of turgor provided by the underwater processing method resulted in increased moisture retention of the precut heat treatment fruit. If more samples were tested, these differences may become significant. If the product is sold by weight, then less weight loss during storage is a definite advantage. More data are needed to confirm the consistency of the occurrence of weight loss reduction. If these methods reduce weight loss, it would be commercially important.

Descriptive Sensory Flavor Evaluation

Changes in flavor and texture during fresh-cut cantaloupe storage have been documented extensively in previously work (Bett-Garber *et al.* 2003; Beaulieu *et al.* 2004; Lamikanra *et al.* 2005, 2010). Therefore, the sensory changes during storage were only discussed if they specifically relate to the treatments.

Of the aromatic flavors, only fruity/melon was significantly affected by the experimental treatments (Fig. 5). The fruity/melon flavor in the control was significantly less intense than the combination—precut heat treatment and underwater cut. The precut heat treated sample and the underwater cut sample intensities were between the range of values, but not significantly different from the untreated control and the combination treatments. Although not significant, sweet aromatic flavor was markedly more intense in the two mildly precut heat treatments than in the control ($P = 0.0503$). Cucurbit flavor was markedly less ($P = 0.068$) in the treated melons than in the control melons. The perception of sweet taste was significantly affected by the three experimental treatments. The control (no treatment) melons were less sweet than the treated melons. As storage progressed, the difference in sweet taste between the treated melons and untreated melons became less profound (Fig. 6). This difference was less at day 8 than at day 1 or 5. Lamikanra *et al.* (2005) observed similar results, although they found the precut heat treatment reduced the off-flavors such as fermented, musty and rancid/painty. These off-flavor attributes were so low in intensity in these melons that there was very little change between treatments. The aroma/flavor/taste quality of fresh-cut cantaloupe during storage appeared to be improved by these treatments over the control melons.

Since melon differences were confounded with the treatment differences, some of the treatment differences could be due in part to an individual melon being different than other melons within the treatment which would make the

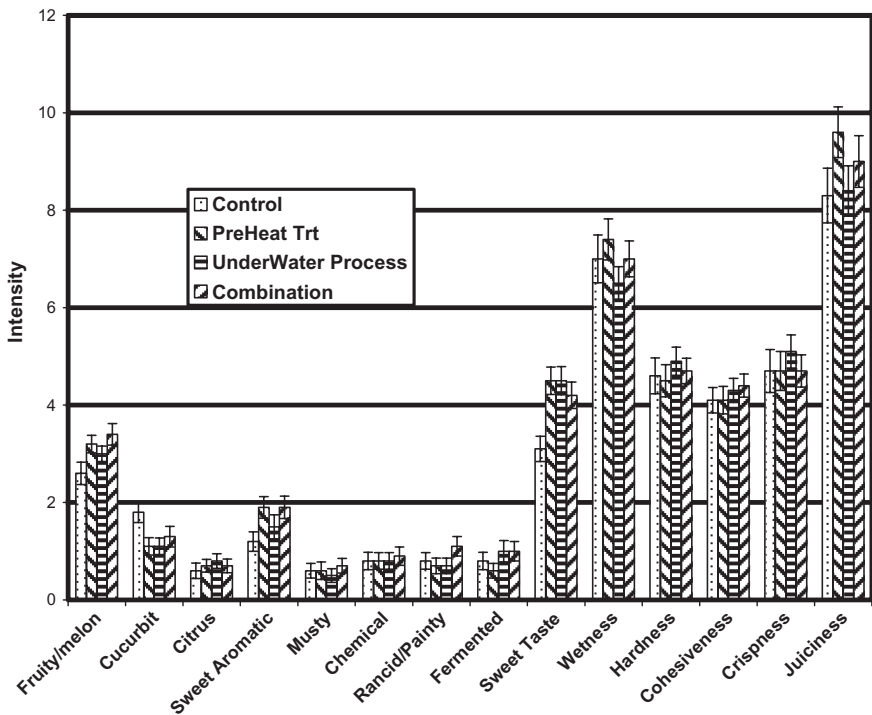


FIG. 5. MEAN INTENSITY OF SENSORY FLAVOR AND TEXTURE ATTRIBUTES OF FRESH-CUT CANTALOUPE SUBMITTED TO FOUR PROCESSING TREATMENTS AND STORED AT 10C

$n = 35$. Processing treatments were: Control = fruit processed in open air (no heat treatment), Preheat Trt = fruit precut heat treatment at 60C for 1 h and refrigerated for 24 h, Underwater Process = fruit with first cut made underwater and held for 5 min, Combination = fruit precut heat treatment at 60C for 1 h and processed underwater. Narrow vertical bars represent standard error of the means.

mean slightly lower or higher than it would have been if all the melons could start out equal. Between this work, previous work (Lamikanra *et al.* 2005, 2010) and some unpublished work, these methods appear to have an effect on fresh-cut fruit quality.

Descriptive Sensory Texture Evaluation

Texture was not significantly affected by the treatments (Fig. 5). Lamikanra *et al.* (2010) reported that cantaloupe hardness increased when cut under water with added calcium. In the current experiment, hardness slightly increased when cut under water with added calcium, but it was not

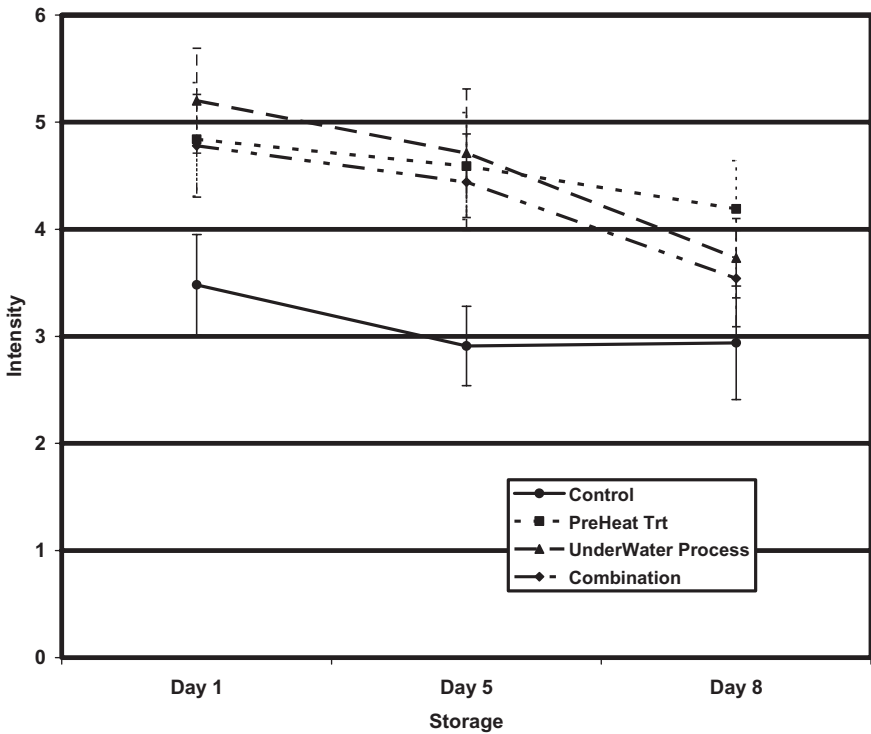


FIG. 6. MEAN INTENSITY OF SWEET TASTE OF FRESH-CUT CANTALOUPE SUBMITTED TO FOUR PROCESSING TREATMENTS AND STORED AT 10C
n = 11. Processing treatments were: Control = fruit processed in open air (no heat treatment), Pre-heat Trt = fruit precut heat treatment at 60C for 1 h and refrigerated for 24 h, Underwater Process = fruit with first cut made underwater and held for 5 min, Combination = fruit precut heat treatment at 60C for 1 h and processed underwater. Vertical bars represent standard error of the means.

significantly different (Fig. 5). Precut heat treatment did not impact the hardness. This agrees with earlier experiments reported by Lamikanra *et al.* (2005) who noted that precut heat treatment did not impact hardness.

From the standpoint of sensory quality, underwater processing had comparable effects on both the fruit processed under water and the precut heated fruit that was underwater processed. However, for the underwater-processed fruit, the benefits of underwater processing were largely derived from the presence of calcium in the treatment water at 4C based on results of Lamikanra *et al.* (2010). With respect to the mildly precut heat treated fruit that was processed underwater, the results show that the benefits were mostly derived from the mild heat treatment that was cooled and held for 24 h before cutting.

CONCLUSIONS

Individually, the precut heat treatment and the underwater-cut treatments improved the storage stability of fresh-cut cantaloupe, but the two combined have only a slight synergistic affect based on respiration during storage. Fruity/melon flavor and sweet taste were greatly increased by all the treatments over the control samples, while sweet aromatic flavor was markedly increased and cucurbit was markedly decreased. Underwater-processed fruit that was precut heat treated also produced fresh-cut fruit that had a lower CO₂ percent of respiration that could help maintain minimal weight loss. The combined treatments did not show a marked improvement on the sensory attributes over the two independent treatments. Both of these treatments are simple to accomplish and have the potential to improve quality of fresh-cut cantaloupe.

REFERENCES

- ADE-OMOWAYE, B., TAIWO, K., ESHTIAGHI, N., ANGERSBACH, A. and KNORR, D. 2003. Comparative evaluation of the effects of pulsed electric field and freezing on cell membrane permeabilisation and mass transfer during dehydration of red bell peppers. *Innov. Food Sci. Emerg. Technol.* 4, 177–188.
- ANNOUS, B.A., BURKE, A. and SITES, J.E. 2004. Surface pasteurization of whole fresh cantaloupes inoculated with *Salmonella* Poona or *Escherichia coli*. *J. Food Prot.* 67, 1876–1885.
- BEAULIEU, J.C., INGRAM, D.A., LEA, J.M. and BETT-GARBER, K.L. 2004. Effect of harvest maturity on the sensory characteristics of fresh-cut cantaloupe. *J. Food Sci.* 69, S250–S258.
- BETT, K.L. 2002. Evaluating sensory quality of fresh-cut fruits and vegetables. In *Fresh-Cut Fruits and Vegetables: Science, Technology, and Market* (O. Lamikanra, ed.) pp. 427–438, CRC Press, Boca Raton, FL.
- BETT-GARBER, K.L., BEAULIEU, J.C. and INGRAM, D.A. 2003. Effect of storage on sensory properties of fresh-cut cantaloupe varieties. *J. Food Qual.* 26, 323–325.
- CABRERA, R.M. and SALTVEIT, M.E. 1993. Characterization of fruit exudates on chilling injury of cucumber fruits. *Acta Hortic.* 343, 290–292.
- COUEY, H.M. 1989. Heat treatment for the control of postharvest diseases and insect pests of fruit. *HortScience* 24, 198–202.
- FALLIK, E. 2004. Prestorage hot water treatments (immersion, rinsing and brushing). *Postharvest Biol. Technol.* 32, 125–134.

- JAVANMARDI, J. and KUBOTA, C. 2006. Variation of lycopene, antioxidant activity, total soluble solids and weight loss of tomato during postharvest storage. *Postharvest Biol. Technol.* *41*, 151–155.
- JOHNSEN, P.B. and KELLY, C.A. 1990. A technique for the quantitative sensory evaluation of farm-raised catfish. *J. Sensory Studies* *4*, 189–199.
- LAMIKANRA, O. and WATSON, M. 2004. Effect of calcium treatment temperature on fresh-cut cantaloupe melon during storage. *J. Food Sci.* *69*, C468–C472.
- LAMIKANRA, O. and WATSON, M.A. 2007. Mild heat and calcium treatment effects on fresh-cut cantaloupe melon during storage. *Food Chem.* *102*, 1383–1388.
- LAMIKANRA, O., BETT-GARBER, K., INGRAM, D. and WATSON, M.A. 2005. Use of mild heat pre-treatment for quality retention of fresh-cut cantaloupe melon. *J. Food Sci.* *70*, C53–C57.
- LAMIKANRA, O., WATSON, M.A. and BETT-GARBER, K.L. 2006. USDA, ARS, New Orleans, LA. Preliminary research on underwater cutting during the first cut resulting in two halves of the melon with the remaining cutting done in air.
- LAMIKANRA, O., BETT-GARBER, K.L., WATSON, M.A. and INGRAM, D.A. 2010. Effect of underwater processing on sensory quality and shelf life of fresh-cut cantaloupe melon. *J. Food Qual.* DOI: 10.1111/j.1745-4557.2010.00315.x.
- LURIE, S. 1998. Postharvest heat treatments. *Postharvest Biol. Technol.* *14*, 257–269.
- MEILGAARD, M., CIVILLE, G.V. and CARR, B.T. 2007. *Sensory Evaluation Techniques*, 4th Ed., CRC Press, Boca Raton, FL.
- SERRANO, M., MARTINEZ-ROMERO, D., CASTILLO, S., GUILLEN, S. and VALERO, D. 2004. Role of calcium and heat treatments in alleviating physiological changes induced by mechanical damage in plum. *Postharvest Biol. Technol.* *34*, 155–167.
- SOLOMON, E.B., HUANG, L., SITES, J.E. and ANNOUS, B.A. 2006. Thermal inactivation of *Salmonella* on cantaloupes using hot water. *J. Food Sci.* *71*, M25–M30.
- ZISHENG, L. 2006. Hot water treatment of postharvest mei fruit to delay ripening. *Hortscience* *41*, 737–740.